

UNCLASSIFIED

Analysis of the Thermal Shielding Properties of Camouflage Materials

John G. Bennett, Erik S. Polsen
U.S. Army TARDEC

**Military Sensing Symposium
Camouflage, Concealment and Deception
Orlando, Florida
5 – 9 February 2007**

Approved for public release; distribution is unlimited

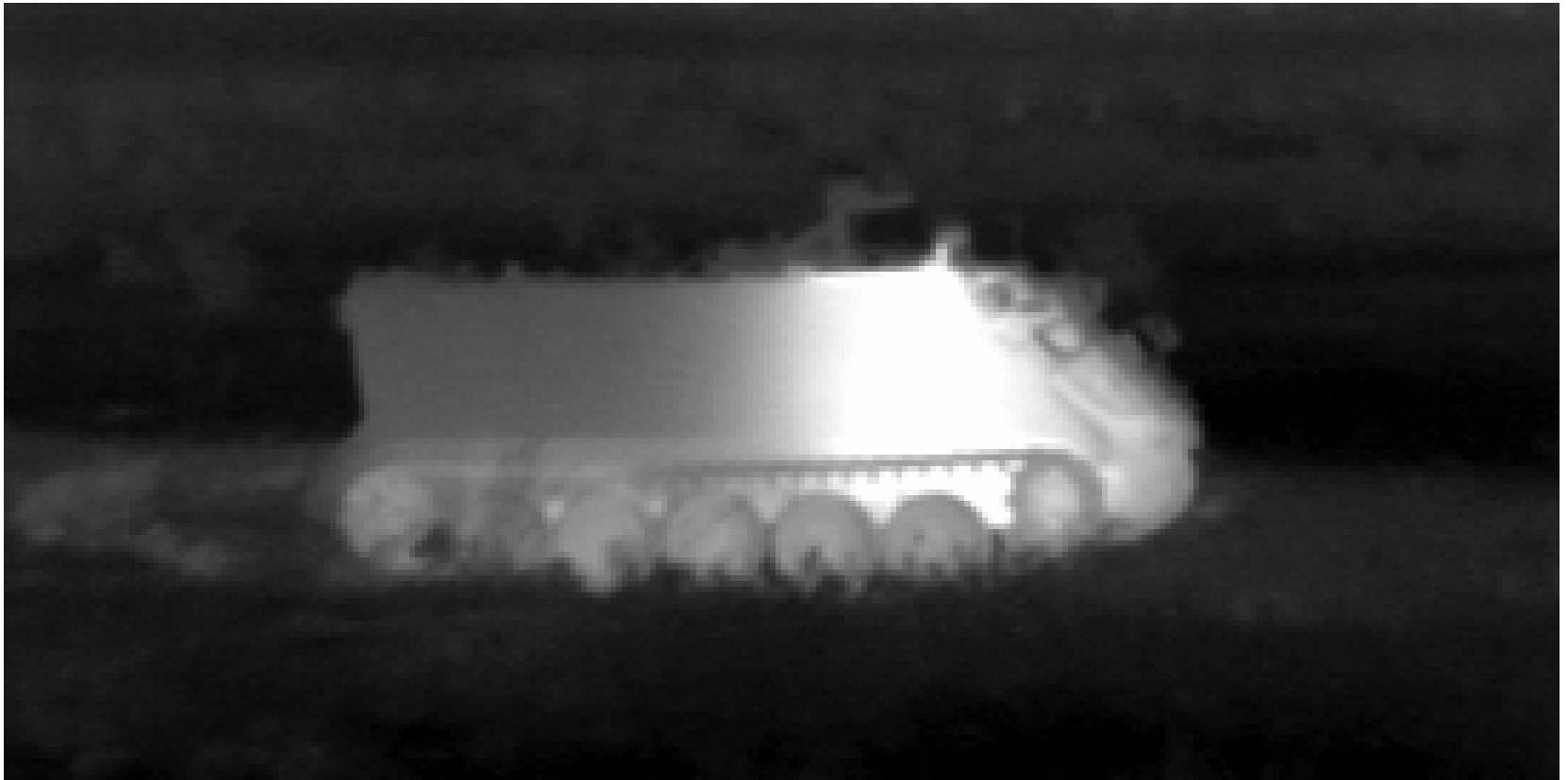
UNCLASSIFIED

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 05 FEB 2007		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Analysis of the Thermal Shielding Properties of Camouflage Materials Brief				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Bennett, John G.; Polsen, Erik S.				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USA ARMY TACOM 6501 E 11 Mile Road Warren, MI 48397-5000				8. PERFORMING ORGANIZATION REPORT NUMBER 16962	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S) TACOM TARDEC	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) 16962	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 17	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Summary

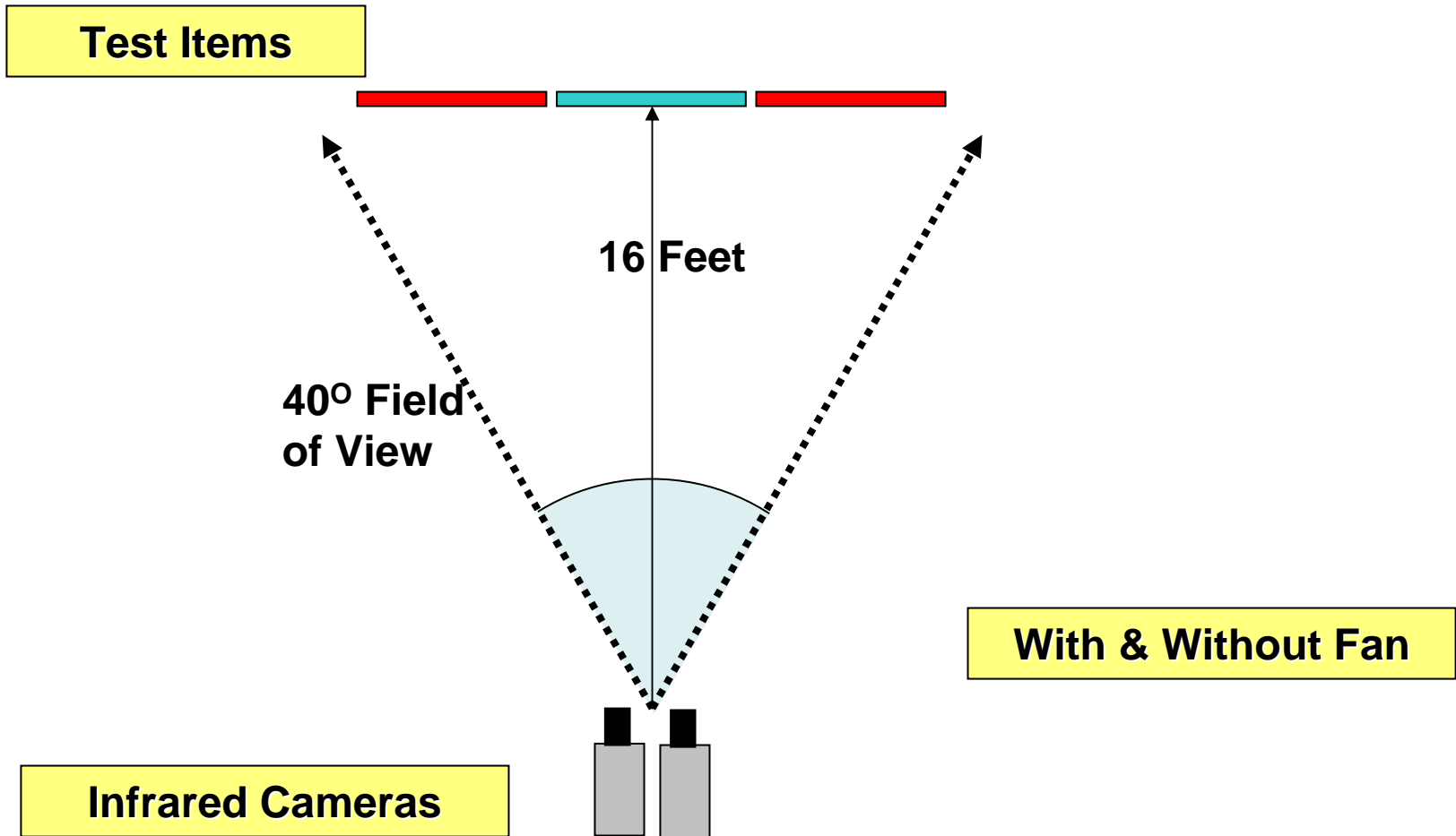
- Thermal Shielding
- Measurement Techniques
- Analysis Techniques
- Results
 - Still Air
 - Flowing Air
- Conclusion

The Problem: Hot Areas Need Thermal Shielding



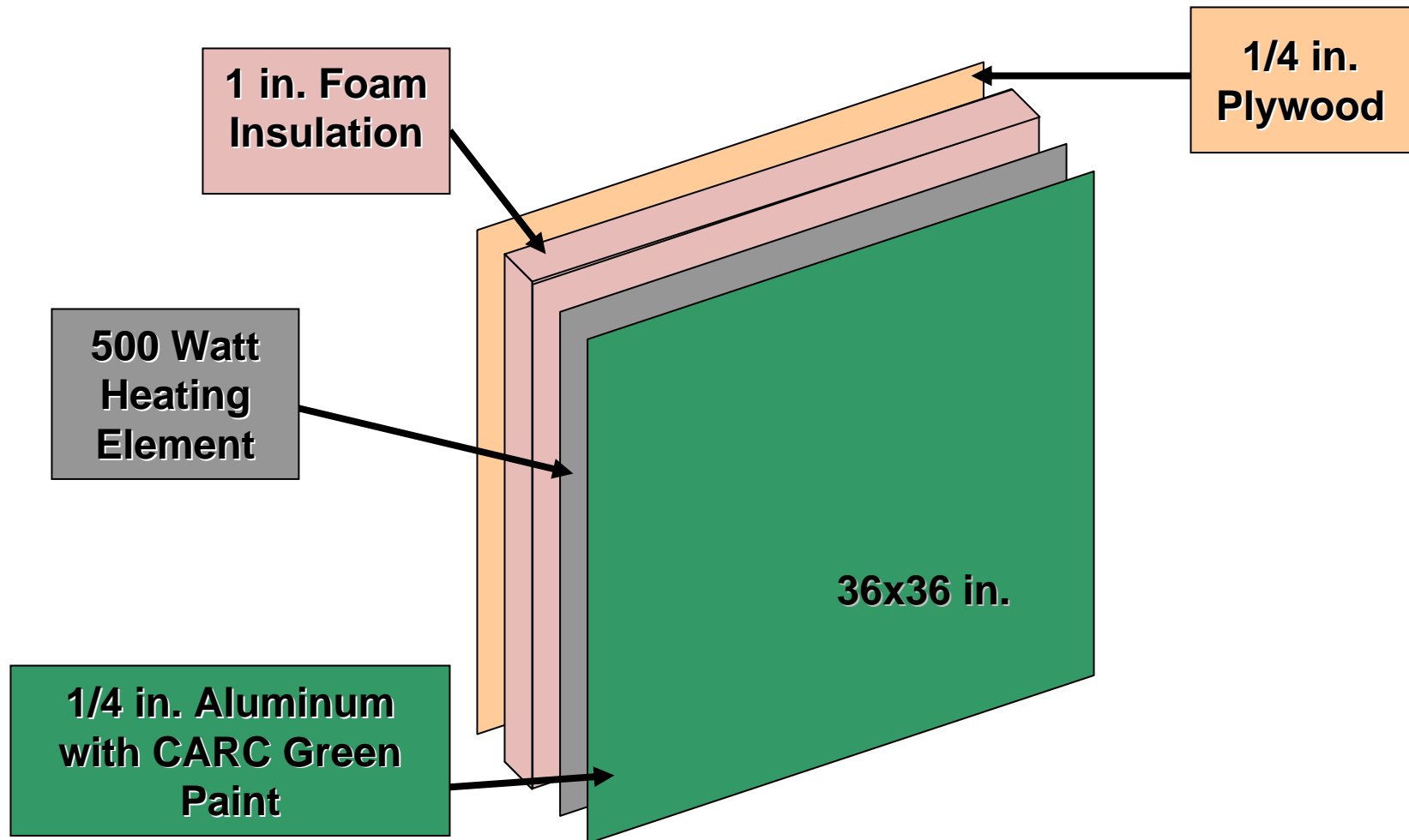
UNCLASSIFIED

Measurement Techniques: Test Setup



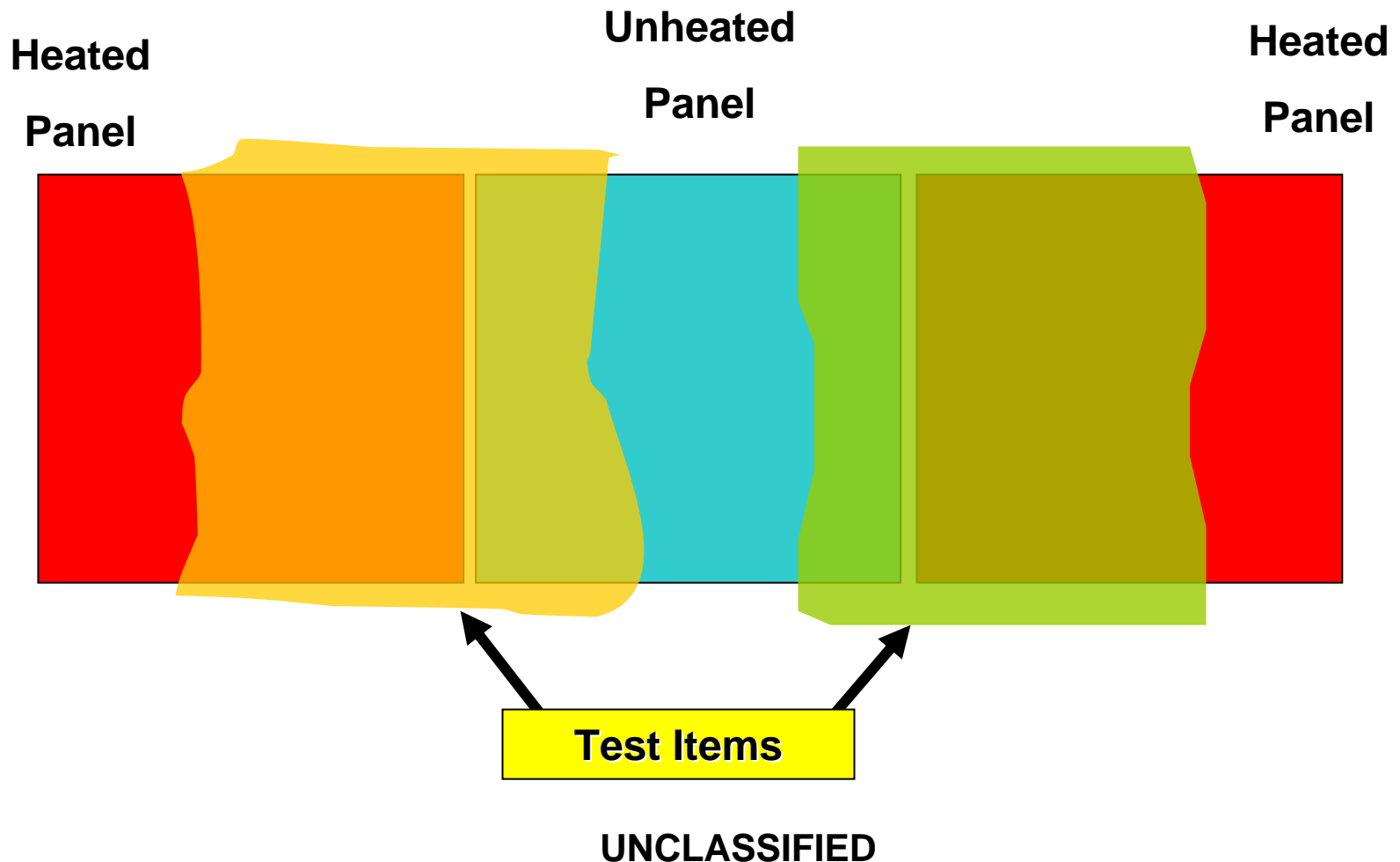
UNCLASSIFIED

Measurement Techniques: Construction of Heated Panels

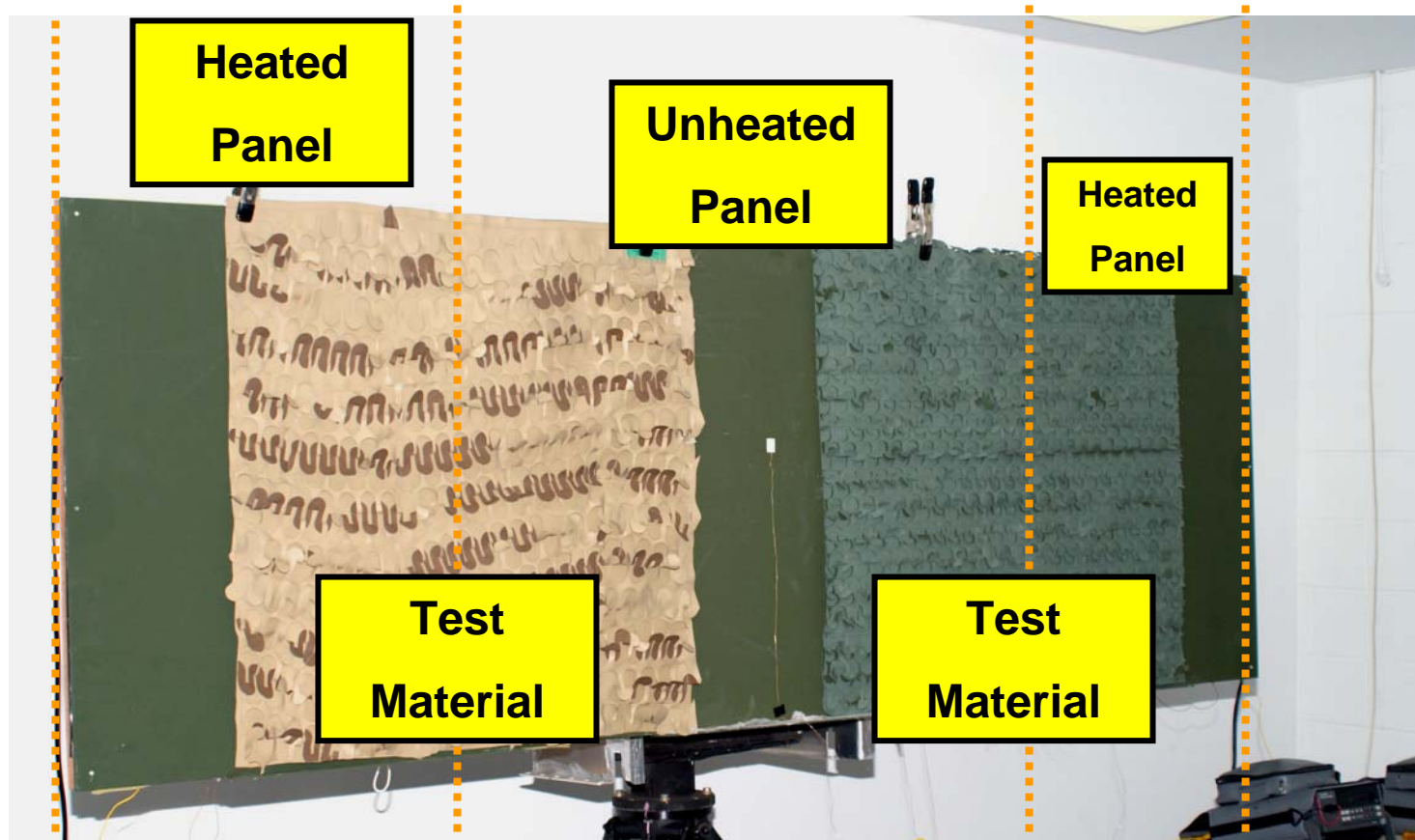


UNCLASSIFIED

Measurement Techniques: Test Setup

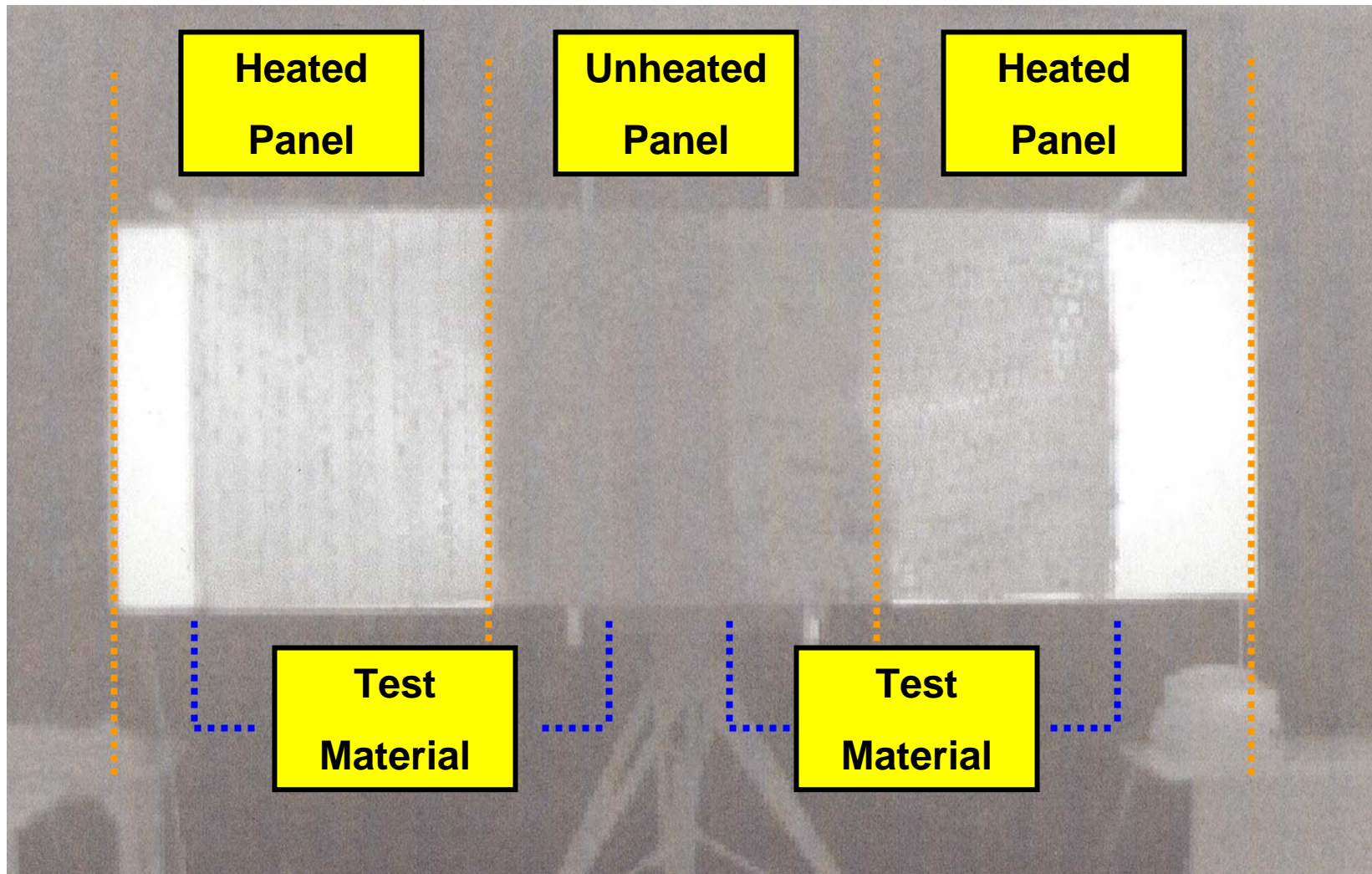


Measurement Techniques: Arrangement of Test Items



UNCLASSIFIED

Measurement Techniques: Arrangement of Test Items

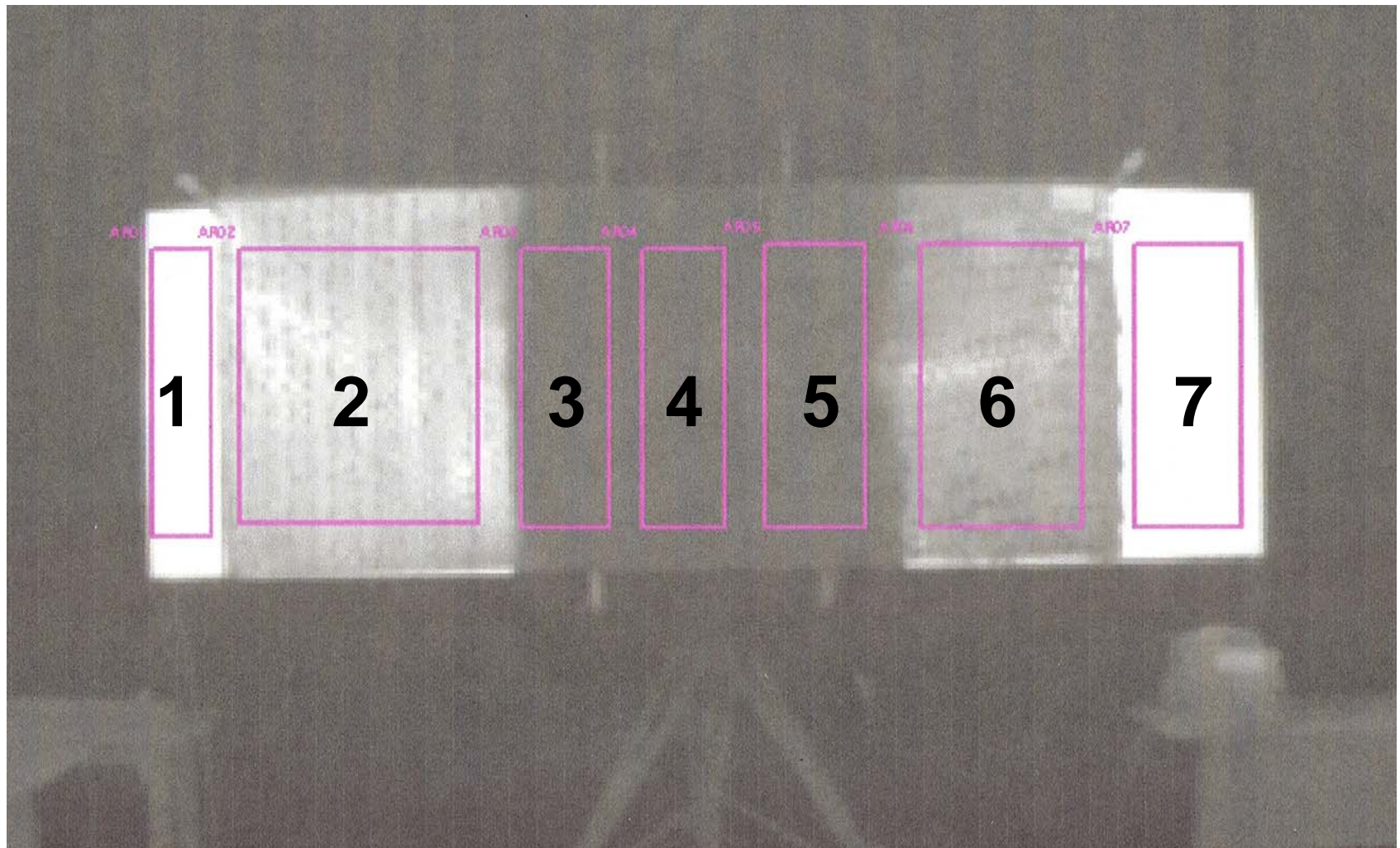


UNCLASSIFIED

Measurement Techniques: Test Procedure

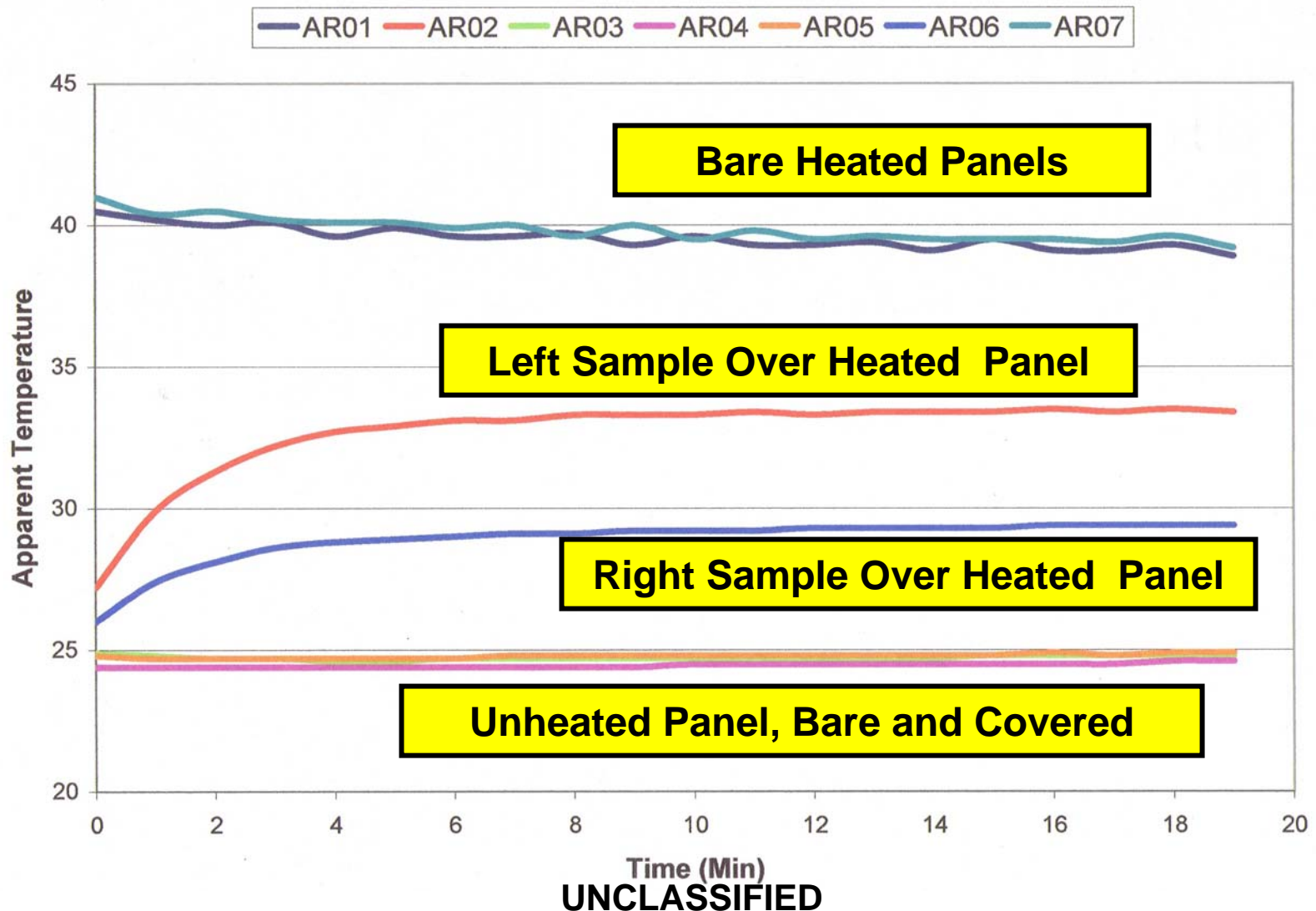
- Allow both panels to stabilize ($\sim 115^{\circ}\text{F}$ without fan)
- Hang test articles on test fixture
- Take thermal imagery (3-5 and 8-12 μm) every minute for 20 minutes
- Repeat test for all test articles with forced convective cooling

Measurement Techniques: Areas of Interest (AOI's)



UNCLASSIFIED

Measurement Techniques: Typical Results



Parameter Estimation

Choose parameters for best least-squares fit to

$$T(t) = T_{final} - (T_{final} - T_{initial})e^{-\frac{t}{\tau}}$$

where the parameters are

$T_{initial}$ = Initial Temperature (measured value)

T_{final} = Ultimate Temperature (fitted parameter)

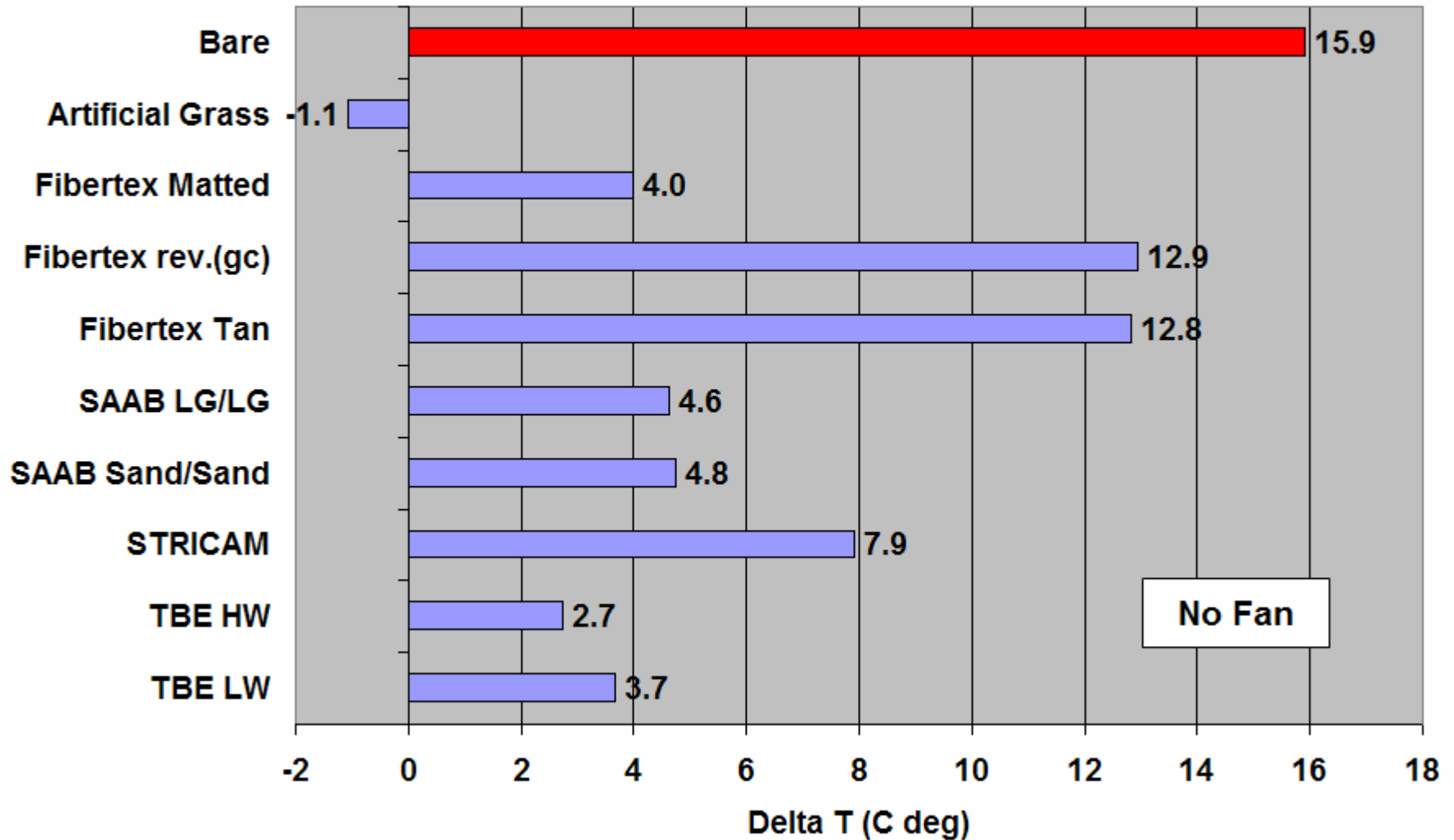
τ = Time Constant (fitted parameter)

Temperature Difference

Compare final temperature of covered heated panel with temperature of unheated panel:

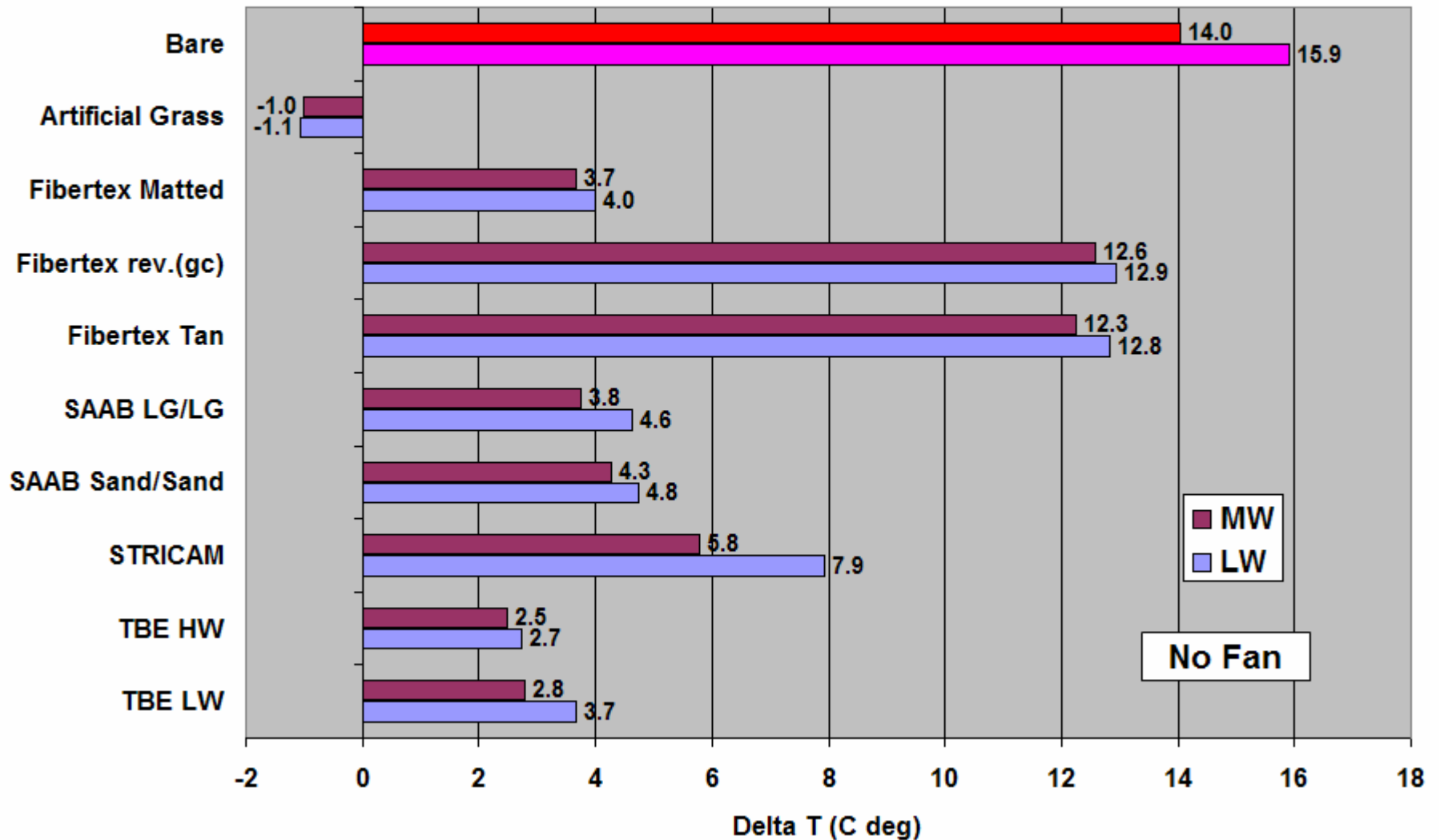
$$\Delta T = T_{final} - T_{unheated\ panel}$$

Temperature Difference, Long Wave IR



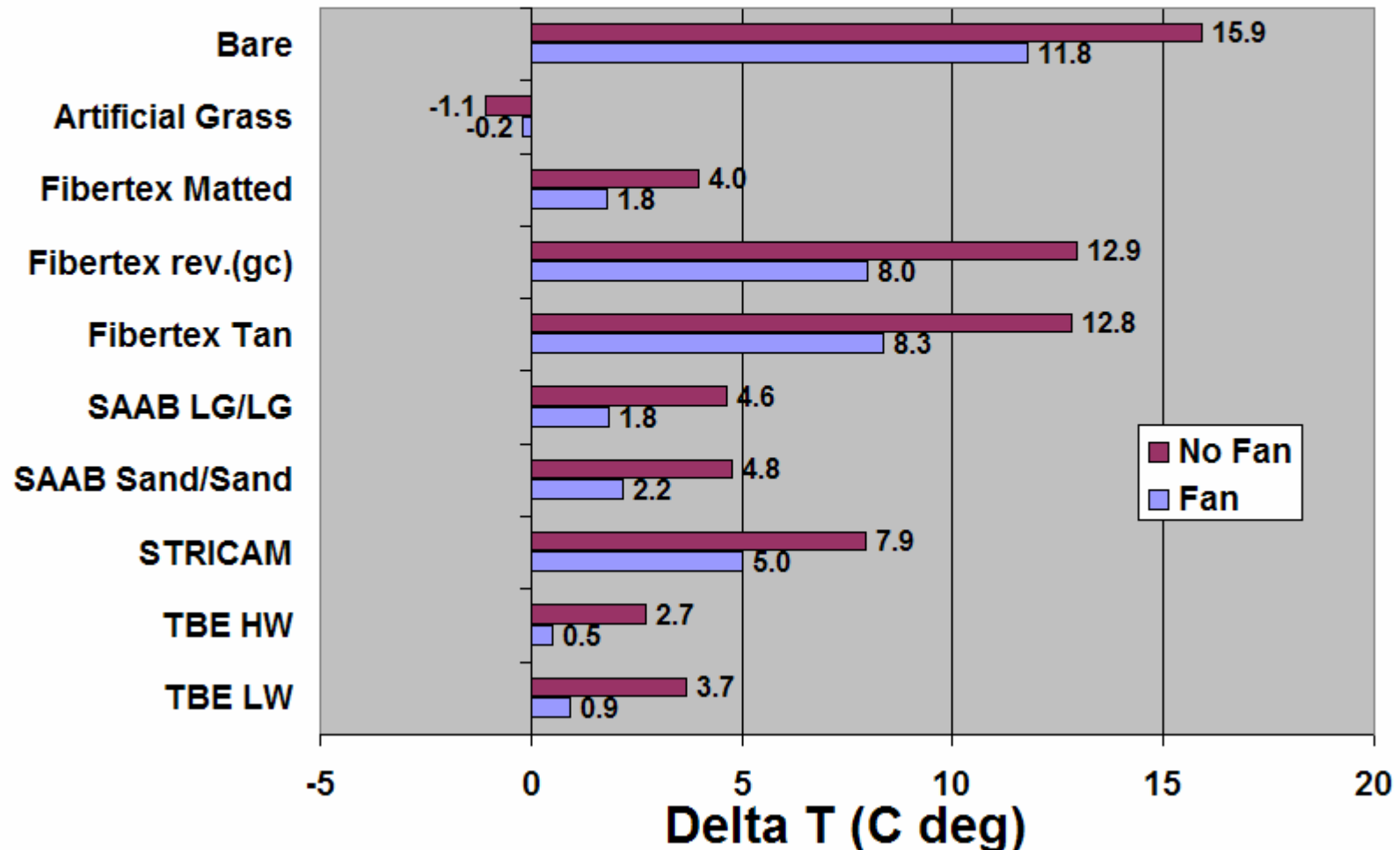
UNCLASSIFIED

Difference in Apparent Temperature Medium and Long Wave IR



UNCLASSIFIED

Temperature Difference, Long Wave IR, with and without Fan



Conclusion

- The techniques shown are suitable for evaluating the thermal shielding performance of camouflage materials
- Air flow has a strong influence on thermal shielding performance of camouflage materials.
- Future measurements should include control of air flow.
- Questions:
 - John Bennett, john.g.bennett@us.army.mil
 - Erik Polsen, erik.s.polsen@us.army.mil